

Interactive comment on “Tropical cyclogenesis in a tropical wave critical layer: easterly waves” by T. J. Dunkerton et al.

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General Comments

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I like the ideas and the approach to testing them. They have a good chance of being substantially correct, and – if they were to become widely understood – should prove valuable as organizing concepts.

The main point is simple but cogent, its typical application being to easterly waves in the Atlantic lower-tropospheric trade winds. The regions of closed streamlines in the Kelvin cat's eye pattern that surrounds a critical line or "latitude", in a horizontally sheared flow subject to a neutral wavy disturbance viewed in its co-moving reference frame,

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are material entities. Therefore, they are liable to experience cumulative heating and moistening by small-scale convection. So we have a strong candidate for cumulative, organized latent-heat release within the cat's eye, diabatically creating a cyclonic PV (potential vorticity) anomaly in the lower troposphere and, in some cases, setting the stage for ignition of a tropical cyclone.

A fundamental aspect, not highlighted very clearly – indeed, obscured by the talk of "cyclonic rollup of mean vorticity in the southern critical layer... concentration of cyclonic vorticity" (page 11164, 16 of 144 in my pdf reader, line 11-13) – is that the kinematics of Kelvin cat's eyes is a generic way to get closed streamlines and closed material contours _without_, at first, needing a co-located concentration of cyclonic vorticity or PV.

Contrary to what's suggested by "cyclonic rollup...", what rolls up within each cat's eye is not pure-cyclonic PV at first. Rather, it's a tightening spiral of PV anomalies of both signs, tending toward mutual annihilation, as was beautifully illustrated long ago in the pioneering work of Stewartson, Warn and Warn (SWW) on the simplest of all relevant critical-layer problems. In other words, in Fig. 1 (from the work of P. H. Haynes on the SWW problem), "yin" and "yang" have equal status. So in this situation the rollup by itself is not an efficient way to create a cyclonic vorticity or PV anomaly. On the contrary – and I think this is the authors' real point – it's not the rollup at all but, rather, the cumulative latent-heat release within the cat's eye that matters for the creation of the cyclonic PV anomaly.

Lines 11-13 read as if there is some conflation or confusion between "cyclonic rollup", in a kinematic sense, and "cyclonic vorticity". Attention is thus distracted from a very fundamental, and very interesting, _dynamical_ aspect.

This is just one among hundreds of examples of a certain linguistic carelessness and, dare I say it, profligacy, in 144 closely-printed pages of presentation. The last thing I want is to damp the authors' enthusiasm. nor be negative about the multitudes of things

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that must have inspired them – in private – but I would urge them to consider that their ideas would have more impact in public, and would try readers' patience much less sorely, if they were to make their presentation more efficient and therefore more cogent not only

(a) by more care and economy in the choice of words, but also

(b) by getting quickly to the key points, pruning large amounts of material that distract attention from them, and re-ordering the flow of argument where necessary.

Here's an example of not getting quickly to a key point. It's not until the end of section 2.1, page 11164, 16 of 144, that we learn that the paper is going to focus on the "downstream propagation of neutral waves on an easterly jet as depicted in Fig 2". This is after a long digression on shear instability and on the content of four subsequent papers on the production line – almost as if the authors were talking to their funding bureaucrats.

I agree with the authors that it's a good idea to concentrate at first on the simplest model that brings out the essential point. And of course there's a great art in presenting no more, but just enough, of the scientific background to help the reader see things in context and sense why that simplest model is interesting, and which particular kinds of TC genesis it tries to illuminate. I'm quite sure all that could be done in far less than half the space, if attention is given both to hard pruning and to re-ordering.

For instance Figure 2 and the neutral waves on an easterly jet could be mentioned almost at the outset, followed by a single sentence saying that such neutral waves might arise from the saturation of growing, shear-unstable disturbances further upstream. It could then be explained that this is thought to apply to the Atlantic and perhaps the east Pacific situations, as distinct from the monsoon trough situation to be dealt with in a subsequent paper.

Coherent ordering is of course not just a means of shortening – drastically in this case

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– but also a means of making the presentation far more cogent and therefore far more persuasive. As noted on a well known web page, if one wants to be cogent then "finding the best order in which to arrange the points of an argument is overwhelmingly important." One payoff is a drastic reduction in the need to say the same thing again and again. As a reader, I get a better sense of what's essential and what's superfluous and, in the words of referee 1, I avoid having to "remind myself of the earlier parts by repeatedly reviewing them."

So, if the authors were willing to do the hard work required, and cut down the total length by a factor of two or three (easily possible, it seems to me), then I'd recommend publication with enthusiasm.

I'll now give a few more specific illustrations of how shortening can be achieved, showing how much it could improve the paper and make it more widely read and understood.

Specific Comments

Considerable shortening could be achieved simply on the level of local wordsmithing. One example is the needless (and muddy) sentence "We simply consider..." at the end of section 2.1. Delete the whole sentence! Another is in the abstract, lines 18-21, where we read

"... one should view the flow streamlines, or stream function, in a frame of reference translating horizontally with the phase propagation of the parent wave. This translation requires an appropriate "gauge" that renders translating streamlines and isopleths of translating stream function approximately equivalent to flow trajectories."

I think most educated readers would agree that the following is not only shorter, but also clearer:

"... one should view the flow streamlines in a frame of reference translating horizontally with the phase propagation of the parent wave. In this co-moving frame, streamlines are approximately equivalent to particle trajectories."

In particular, the "gauge" idea is not only needless but technically wrong – inspiring though it may have been in private. The authors are talking about a Galilean transformation. It is not a gauge transformation. (Yes, Galilean transformations and gauge transformations are both mathematical transformations. But the resemblance ends there. Indeed, the contrast couldn't be starker: going one step away from Galilean transformations to Lorentz transformations, Lorentz with a t , we are reminded that there's no such thing as the co-moving frame of an electromagnetic wave!)

Notice by the way that I'm agreeing with David Raymond's comment about words like "Lagrangian" and "material". It seems to me pointless to use those words in an unconventional sense, given that their technical meanings are stable in the community, and widely used and accepted. I'm also following Strunk and White's famous plea, "omit needless words". Following up the point about gauge transformations a little further, one can see that practically all of page 11183 (35 of 144) could be deleted with advantage, including footnote 23. String-searching the giant pdf yields over 60 occurrences of the word "gauge", suggesting possibilities for shortening elsewhere as well.

Please don't think that I'm against a degree of unconventionality. It's fine if there's a point to it. Take for instance "The critical layer.. represents a sweet spot for tropical cyclogenesis" (Abstract, line 10). I like the "sweet spot". That's both unconventional and poetic, but there's a point to it because an insight is suggested and made a bit more memorable. However, the impact is weakened by the use of an undefined term in an unconventional sense. The undefined term is "critical layer". Conventionally, it means the Kelvin cat's eye pattern and its immediate surroundings. This has finite width at all longitudes x – hence "layer", in a sideways sense. So a clearer version with just as much poetry, but more impact, would be "A Kelvin cat's eye.. is a sweet spot for tropical cyclogenesis..".

To make that work, all the authors need to do is to introduce the term "cat's eye" in the previous sentence. That's efficient because the term will be used later in any case (coherent ordering again.) So the second sentence of the abstract needs a tiny change

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(line 6): "This structure.. resembles the familiar Kelvin cat's eye pattern of waves in shear flow, a flow configuration that arguably provides..." ["that," not "which", by the way; again see Strunk and White. It's not compulsory but it's just another tiny thing that works for clarity and against muddiness.]

And why "resembles"? Even better would be "This structure is the familiar Kelvin cat's eye pattern of waves in shear flow, a flow configuration that arguably provides..." Also, for the sake of coherent ordering, the phrase "Equatorward of the easterly jet axis" belongs to the "sweet spot" sentence and not earlier: "A Kelvin cat's eye equatorward of the easterly jet axis is a sweet spot for tropical cyclogenesis..".

If the authors would like to check the solid theoretical reasons for considering the critical layer to have finite width at all x , there's a readable review of SWW in Killworth and McIntyre (J. Fluid Mech. 161, 449 and <http://www.atm.damtp.cam.ac.uk/people/mem/km-index.html>). The SWW work and its successors used matched asymptotics to make exquisitely precise what is, or dynamically speaking should be, meant by "the critical layer". The dynamics of its interaction with the wavy flow outside is described precisely and self-consistently by the same analysis. And the Kelvin cat's eyes form only the innermost part of the critical layer, not the whole critical layer.

[SWW supplemented by the Taylor-Bretherton identity is also, I've always thought, the most cogent of all theoretical models showing not only why waves and turbulence co-exist (footnote 3) but also showing why, in dynamical systems of this kind, "there's no such thing as turbulence without waves". But now _I'm_ straying a bit.]

Coming back to the issue of coherent ordering within the abstract, I'm suggesting that the phrase "critical layer" can be replaced by "cat's eyes" or "cat's eye" throughout the abstract. Then another needless word, "effectively", can be deleted from line 22, where a more streamlined version would be

"In the co-moving frame, the closed circulation is stationary, and a dividing streamline

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separates air within the cat's eyes from air outside. A cat's eye equatorward of the easterly jet axis is important because..."

As also noted on the web page mentioned earlier, "Context is built before new points are introduced." Thus, to prepare "marsupial" on line 17 of the abstract – completely unintelligible as it stands – line 11 needs to become something like "proto-vortex may form and grow within its parent wave, like a marsupial infant in its mother's pouch."

There's another needless word, "resolved", in line 25. That would make sense had it been prepared by some statement that attention has switched from the real atmosphere to a numerical model. (But I'd say it's clearer and simpler to stay focused on the real atmosphere here.)

And similarly throughout the 144 pages. Surely I don't need to multiply examples, and indeed that would be impossible because I'm forbidden to make this report longer than 15 pages (in some format that one has to guess). From personal knowledge I consider the authors to be extremely bright and creative scientists, and I doubt if they need any more suggestions from me – except maybe one:

Do consider reducing the number of synonyms or near-synonyms that denote a single entity, and consider using a reduced vocabulary consistently. Sometimes these synonyms have a point, or would have a point if the wordsmithing were improved. But others are, I suspect, just gratuitous variations that got thrown in. For instance there's a single entity that's variously referred to as the "cat's eye", the "gyre", the "recirculation region", the "closed stream function gyre", the "vortex" (not technically correct if "vortex" has its standard meaning, a PV anomaly together with its induced flow), the "proto-vortex" (good!), the "embryo", the "seedling", the "joey", the "pouch", the "baby pouch", and so on.

There is a great deal of pleonastic duplication scattered around, e.g. "ambient environment" (cf. "true fact" or "vocal singing"), and semi-pleonastic constructions of the type "cats and felines", as in "cats _and_ felines eat meat". Even on the first two pages I

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find the following:

"material surfaces _and_ Lagrangian boundaries", line 7 on page 11152 (4 of 144);

"translating streamlines _and_ isopleths of translating stream function", lines 20-21 of the Abstract;

"in the tropics _and_ in regions..such as the ITCZ", line 7 on page 11153 (5 of 144)
(as if the ITCZ were distinct from, or separate from, the tropics).

I don't want to take a hard line about the welter of footnotes since, with those at least, I have the option of ignoring them all. Nevertheless, the authors should ask themselves whether all those footnotes are worth public space. As with parts of the present text, some of the material seems to be more in the nature of private working notes.

Technical Corrections:

There is no room for a list of these within the permitted space. Besides, if the needed rewriting is done, most of them will go away. Among the advantages of an economical, coherently-ordered presentation is that the authors themselves can more easily pick up any errors.

There are a few acronyms not defined at first occurrence; please watch out for these, and consider whether some of the very many acronyms are, so to speak, earning their living.

(One technical error that mightn't go away is a repetition of the myth that shear instability requires a particular sign of the PV gradient at the critical line. This myth – perhaps promoted by the "over-reflection" paradigm for shear instability – can be instantly dispelled by considering a few examples beginning with the Eady instability. This has zero PV gradient at its critical line. So the over-reflection paradigm is irrelevant. Indeed, it makes an incorrect prediction, that the Eady flow is stable! The paradigm is useful in some cases and not others. It is useful for instance in the shear instability problem con-

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sidered in 1965 by A. E. Gill (Phys. Fluids. 8, 1428), as Gill demonstrates. However, the point is probably more relevant to subsequent papers than to this one.)

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 11149, 2008.

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