Atmos. Chem. Phys. Discuss., 12, C9190–C9193, 2012
www.atmos-chem-phys-discuss.net/12/C9190/2012/

Atmospheric Chemistry and Physics Discussions

ACPD

12, C9190–C9193, 2012

Interactive Comment

Interactive comment on "Height increase of the melting level stability anomaly in the tropics" *by* I. Folkins

Anonymous Referee #3

Received and published: 11 November 2012

The subject of this paper is the layer between 3-5 km in regions of active tropical convection in which atmospheric stability deviates markedly from that produced by simple moist ascent. Johnson et al [1999] had drawn attention to a level of enhanced stability at the melting level in the COARE intensive flux array, and related this to the height of cumulus congestus echo tops. In Folkins [2009], the author developed a one-dimensional model in which mesoscale downdrafts forming below precipitating stratiform anvils produce stability and relative humidity anomalies similar in structure to those observed in a tropical radiosonde climatology. In the present paper, the author uses a radiosonde dataset from the western Pacific to examine the response of this 'melting-level stability anomaly' (MLSA) to changes in near-surface temperatures, the goal being to show that the response is consistent with the hypothesis that the MLSA is due to a rapid increase of stratiform downdraft mass flux below th melting level.

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

The author's approach is to examine profiles of monthly mean of temperature, pressure and relative humidity over the period from 1998-2008 at a set of 5 sonde stations in the western Pacific gridded at 200 m intervals. In Figure 1, the time-averaged sonde data show a deep layer from 2 to 7 km within which lapse rates exceed a representative pseudoabatic lapse rate, with a relative lapse rate minimum at 4 km and relative maximum at ∼5.5 km. The latter defines the upper edge of the MLSA. Temperature anomalies at each grid height are then scattered against the temperature anomalies below 1 km (called 'near surface anomlies') to derive the change in temperature at each height for a 1-degree near-surface anomaly. The resulting response profile in Figure 5, which only begins to go negative at 16 km, has some subtle structure within the MLSA – i.e. a relative maximum in the response near 3.5 km and relative minima near 2 and another near the 5.5 km.

(Error bars on the temperature response profile would also seem to be in order, particularly as the r2 values throughout the free troposphere plotted in the figure are on the order of a third.)

The author states that these changes are consistent with an upward displacement of the MLSA. This is evident from the lapse rate plot in Figure 7, though the 'warm' lapse rate differs from the background in other ways besides a simple upward shift. For example, one could alternatively interpret the warm lapse rate layer above 4 km as more stable and deeper than the background lapse rate.

However the change to the "warm" lapse rate and its effects on the MLSA are interpreted, the results do make physical sense – in particular the pressure response shown in Figure 6. Nevertheless, the fundamental approach used here is to calculate the 'warm' response of the atmosphere at each level independently (as stated in the first paragraph of §3.3) – coupling of anomalies in the vertical is not taken into account. A more complex analysis might not be warranted here – after all 11 years of monthly anomalies does not make a large dataset, but I think a more thorough physical justification of the simple approach that was adopted would benefit the argument.

In Section 3.6 the response of CMIP models to a near-surface warming is calculated and compared to the response in the five-station radiosonde set. As stated in the final sentence of the first paragraph in this section, the goal is to show that the amplification factors calculated with the models are similar to those with the radiosonde data. Based on Figure 8, the author concludes that they are similar. I would agree that they are similar to the extent that the amplification factors are substantially lower than the moist adiabatic. Nevertheless, the models' response in the upper troposphere is much smaller than the sonde response, and taken as a group, the six climate models fail to reproduce the enhanced temperature response in the MLSA seen with the radiosondes. (Although one, the NCAR CCSM3 model, does exhibit a stability minimum at 4 km.) Given that the focus of the paper is on the MLSA and its physical basis, it is not made clear to the reader how the amplification factor calculated for the upper troposphere is relevant in the first place. This is especially so considering the clear difference in amplification factors between the models and the sondes in the lower atmosphere. A link is not made explicitly until the sentence beginning on line 28 in the Conclusions section. Here the lack of the large upper tropospheric amplification factors of a moist adiabatic response in the radiosonde and model data sets is attributed to the 'complex response' in the lower troposphere. How this happens is not discussed however, but it certainly cannot be related to the response of the MLSA, since that is missing in all but one of the six CMIP models examined here.

To summarize this point, it seems to this reviewer that the CMIP model analysis and the tie-in to the larger controversy about large-scale response the atmosphere to a warmer tropical sea surface are not clearly relevant to the question posed in the abstract, that is whether or not a warmer sea surface temperature shifts the MLSA upward. The answer to this question is clearly yes, although the simple methodology used to address the question does relatively little to reveal the physical significance of the result. Once a response was established in Figures 5-7, this discussion thread is more or less abandoned and the author shifts to a rather different discussion with a focus on the amplification factors. There are hints at various places throughout the text to the verti-

ACPD

12, C9190–C9193, 2012

Interactive Comment

cal coupling of the tropical atmosphere through convection, rainfall, large-scale subsidence and other processes, but they are not brought together in a clear statement of how these would influence the MLSA or the more general context of the trimodal structure of the tropical atmosphere. This is a disappointment, as I was hoping for rather more from this author, who has a justifiably admirable record of original contributions.

Errors in the text:

I found two errors in the References:

1. Johnson et al appeared in J. Climate, 12.

2. Redelsperger et al appeared in J. Atmos. Sci., 59.

Recommendation:

Despite the diffuse and at times cryptic nature of the argument, the author clearly has a grasp of the complexities of the issue at hand. It could even be said that the paper in its present form pursues two separate issues. My suggestion is that the paper be accepted for publication with the recommendation that the text be revised so as to more clearly subordinate the amplification issues to the question of the physical underlying processes controlling the MLSA.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 11567, 2012.