Atmos. Chem. Phys. Discuss., 8, S8998–S9000, 2008
www.atmos-chem-phys-discuss.net/8/S8998/2008/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "On the validity of representing hurricanes as Carnot heat engine" *by* A. M. Makarieva et al.

A. M. Makarieva et al.

Received and published: 12 November 2008

We appreciate further attention of Dr. Meesters to our work. We would like to point out that our replies are written by our group of authors (Makarieva, Gorshkov, Li) (rather than "produced by Dr. Makarieva" as Dr. Meesters stated). This can be clearly seen from the authorship of the corresponding Author Comments.

On pp. S8980-S8982 of his new comments (hereafter SCM2) Dr. Meesters calculates the well-known difference between the dry and moist adiabatic lapse rates to arrive at an equally well-known conclusion that "for the same lifting" $pv = RT$ is larger for wet air than for dry air. Indeed, it is so: the moist adiabaitic lapse rate is smaller than the dry adiabatic lapse rate. (Note that the formula for moist adiabatic gradient is explicitly derived in Eq. (11) of Makarieva et al. (2008) ACPD 8: S7609, see also correction on p. S8344 of Makarieva et al. (2008) ACPD 8: S8340.)

This fact is, however, irrelevant for the physical effect under discussion. Contrary to what is suggested in (SCM2), it does not imply either "explosion" or "anti-explosion". Dry air can be in aero- and hydrostatic equilibrium at any value of lapse rate. What is relevant is that when ***at a given lapse rate larger than the critical value of 1.2*** **K km**$^{-1}$ an air parcel lifts and its temperature drops, water vapor, unlike all other gases, disappears from the gas phase producing a non-equilibrium drop of pressure. Indeed, in equilibrium (in the gravity field), as the gas parcel lifts, change of its pressure must strictly obey the equilibrium Boltzmann distribution prescribed by ***gravity***. Saturated water vapor, ruled by the ***vertical temperature drop*** instead, disobeys this distribution and cunningly disappears from the gas phase as the parcel lifts. For this reason, there appears an uncompensated pressure gradient force acting in the upward direction. We refer the reader to our preceding comment (Makarieva et al. (2008) ACPD 8: S8904) made in response to Anonymous Referee 2, where the physical nature of this force is quantified in detail, see also (Makarieva, Gorshkov (2007) HESS 11: 1013).

Here, to illustrate that latent heat release plays no role in the considered effect once the temperature gradient is given, consider the following example: there are two closed vessels placed horizontally on the ground near each other. Both contain pure saturated water vapor, but the left vessel is kept at +100 degrees Celsius, and the right one at -100 degrees Celsius. Clearly, there is a strong pressure gradient between the two vessels, as the right vessel has a practically zero water vapor pressure compared to the left one. If the partition between the vessels is removed, gas from the left vessel will flow as wind to the right vessel. It will then undergo condensation which will sustatin the pressure gradient (provided temperature of the vessels is kept constant). This dynamic gas flow is, in the extreme, what happens in the atmosphere, where the left vessel corresponds to the warmer surface and the right vessel to the upper colder atmosphere.

Regarding the implications for atmospheric circulation, we again refer the reader to our comment on "Condensation as Air Circulation Driver" (Makarieva et al. (2008) ACPD 8: S8904), where these are considered in all the details that are so far available. What suprised Dr. Meesters, that the proposed approach would imply that "the pushing force in upper layers causes local thinning of the air, but this causes lower pressure and hence horizontal convergence in the lower layers" and at the same time "a horizontal contraction and densification in the upper layers, and hence (by the greater weight of the column) a larger pressure in the lower layers" is, as we already noted, a trivial property of atmospheric circulation. If air flows along a close trajectory, it somewhere rises (and in this region surface pressure is low and upper layers rarified) and somewhere descends (and here surface pressure is high and upper layers densified). The mechanism proposed in the DP predicts that the air will rise where condensation (and, hence, rarification of the upper layers due to water vapor disappearance from the gas phase) is more intense and descend where condensation is weak or absent. We disagree with the last phrase in (SCM2): these effects ARE important for this discussion.

On p. S8982 of (SCM2) it is stated that "many people are curious about the implications of the new treatment proposed in section 4 of the DP." As authors, we are deligthed to know that our study raises further interest and would like to use this opportunity to invite all interested people to ask their questions openly in this discussion or directly approach the authors. Our primary goal is that environmental science could make use of our findings to facilitate solution of our common global problems. We are sparing no efforts to explain our findings both in this discussion (and we also did so in the previous one in HESSD) as well as in individual correspondence with ALL interested parties. We are also developing visual aids and animations to facilitate integration of our research into environmental science (www.bioticregulation.ru/pump/pump4.php). We believe this constructive side of our paper is by far more important than the part containing the critique of the existing approaches.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 17423, 2008.