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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

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

Anonymous Referee #2

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In the main part of the discussion paper [DP, 1] the authors present a straightforward critique of published thermodynamic theory of hurricanes. Additionally, the authors offer a brief outline of a new physical theory for explanation of hurricanes as well as other rotating wind structures that develop as individualized extreme atmospheric circulations. The physical reasoning presented in the DP critique of the current thermodynamic models of hurricanes sits solidly on well established thermodynamic laws, and completely ignores other numerical features of those models, including how well they can capture observable hurricane behavior in their simulations. Therefore, from the start, the nature of this critique is absolutely new in the current meteorological literature. Strikingly different from virtually any other paper dealing with hurricane models, these authors have taken a plunge into the internal physical workings of a hurricane

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model, which thus far is thought to conform neatly to all known atmospheric physical principles. But they report that, au contraire, the representation of hurricanes as a natural Carnot engine in current theoretical models of hurricanes [reviewed in 2 and others cited in the DP] violates the laws of thermodynamics, which implies those models would be physically flawed.

This aggravated claim could be disputable had the authors relied on traditional numerical dwellings prevalent in the environmental modeling literature [3]. But in sections 2 and 3 of the DP a physically rigorous deconstruction of the Carnot formulation, formatted more like a logical mathematical proof, presents convincing physical evidence that indeed the current hurricane physical representation in models is fundamentally flawed. Nonetheless, these hurricane model simulations show brilliant agreement with data, they look like data themselves. Physical inconsistencies in atmospheric models, or in any environmental numerical model for that matter, are nothing new. Numerical environmental models are built using small doses of available (poor) physical representation of phenomena and larger doses of statistical fitting of (poor) observational data on the phenomena [3]. All too often whole families of sophisticated models inherit sparse and dubious physical representations from earlier models, a transmission that progresses after a few generations into true physics black boxes, no one really knows how it works, but that functions for the applications at hand. The somewhat vague and generalized perception that atmospheric physics is resolved for any practical purpose conflicts with the more limited awareness that atmospheric physics is far from being sufficiently known. Numerical parameterization in atmospheric models has become a fix-all strategy for missing physics, which suggests that meteorology and other disciplines dealing with environmental modeling are more in tune with engineering than with deep fundamental science. Model repair by "judicious tampering" with model parameters [4] is recognized as an equivalent, full-right alternative to an explicit account of physical phenomena [4, p. 594] when improving the models performance.

Kerry Emanuel himself has pointed out [2] that "hurricanes have received surprisingly

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little attention from theoretically inclined fluid dynamicists", adding that complex thermodynamics and lack of laboratory analogues could perhaps be the reason for such lack of interest from theoreticians. The present DP, it appears, is a first response from theoreticians, bringing an accessible, simple and elegant analysis of atmospheric physics, demonstrating that in fact the current thermodynamics of hurricanes in models is not complex, it is just plain wrong. And here this review comes to a worrying realization: the physical flaw reported in this DP is so fundamental that it is unconceivable that peer review of the highest ranks did not spot and bar it earlier. Mistakes of such magnitude are quite different from smaller physical inconsistencies. The first and second laws of thermodynamics are the science bases. How have then these physical flaws survived the peer review unscathed, for the relevant papers to appear in the top scientific journals, including Nature [5] and even Physics Today [6]? The most likely answer to this shocking reality might lie in the similarly shocking fact that these days nobody really looks into the physics of climate models.

It happens when "good agreement with the data" shortcuts any further analysis of model physical structure. Lahsen [3] analyzing uncertainty in GCMs identified a few interrelated factors that bear relevance to this discussion. The factor that "social and psychological factors can reduce modeler's ability to retain critical distance from their own creations" is especially relevant in meteorological models where the embarked physical appropriateness ends up reliant of solitary scrutiny from the model creator, once nobody else will want to dig there. Another factor was that "Identification of some model inaccuracies requires empirical understanding more prevalent among empiricists than modelers". One could add now that identification of model physical errors requires physical understanding more prevalent among theoretical physicists rather than climate modelers. This would explain why the most qualified atmospheric modelers who had reviewed such series of seminal hurricane papers overlooked the errors that are analyzed in the present DP. In summary, it appears that the community-wide condescendence with this blatant physical flaw in hurricane models is a revealing indication that the modeling community is overly focused on the mimicking capacity of their own

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numerical constructs: the perpetuum mobile hurricane model agrees perfectly with the data [5]! I believe that this hurricane case should be considered with all responsibility as an exposed symptom of a serious chronic disease of the entire climate modeling enterprise.

No one can diminish the importance of the environmental modeling in creating awareness and reaching out to the humanity by and large. The IPCC Nobel Prize last year is a glaring recognition of the importance of such applied science to the present moment of humanity. Still, it is relevant to the point raised in this review that it was a prize in peace, not in physics. The Earth System is an environment of fascinating and complex physical problems. Nonetheless, most deep thinking physicists preferred to look away, smashing atomic nuclei or gazing to the edges of the universe in search for a theory of everything. Meteorologists and other environmental scientists, not enjoying the glamour (or funding) of "big" physics, had to resort to practical approaches that people could value, thus the environmental modeling was born more like an engineering rendition of common phenomena rather than as an accurate physical representation of them. The recent landslide of "non-linearities" in the accelerating greenhouse is quickly making it evident that models "fitted" to historical data, which lack accurate physical representation of the portrayed phenomena, are no longer apt to predict climate trends, even in the shortest term. The spontaneous interest of theoretical physicists for atmospheric problems, as is demonstrated in this DP, is an auspicious sign that the traditional atmospheric modeling community might finally get all the theoretical help it so much needs to produce a quantum leap in their capacity to aptly simulate the Earth system. As such, I believe that the community should welcome criticism and formulations as these. An analysis like that in the DP, i.e. delving into all the numerical complexities behind the solid appearance of the models to find and scrutinize their physical bases, should present a great intellectual as well as emotional challenge. I very much appreciate that the present authors have accomplished this (so far unprecedented) task and offered their findings to the open discussion by the meteorological community and beyond.

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In the second part of the DP, the authors offer a physical representation of hurricanes that can overcome major limitations of the present approach, which relies mostly on complicated parameterization and data tuning (on top of wrong physics). Hurricane as reverse explosion in slow motion is a very simple, intuitive, elegant and powerful explanation that can be generalized to any other similar extreme event in the atmosphere. The physical fundament upon which the main part of this novel theory for hurricanes rests has been developed by the same group in previous work, which was extensively discussed and published in another EGU open review journal [7]. There they introduced and physically explained the evaporative force, which has been overlooked by atmospheric science. The concept is based on another well known conundrum of gas physics, that a local gaseous component that undergoes phase transition changes local pressure, which then promotes the appearance of wind propelling pressure gradients. Classic meteorology has borrowed many concepts from hydraulics, like the notion that local difference of solute concentration in an (incompressible) liquid produces no pressure gradients, only diffusion gradients. In the atmosphere, vertical gradient of temperature leads to an extinction rate of water vapor with height, which was previously interpreted as irrelevant for circulation (difference in concentration of a gas solute should produce diffusive gradient which are orders of magnitude smaller than eddy transport, therefore irrelevant). But these authors have unequivocally demonstrated that in the (compressible) gaseous mixture of the atmosphere local difference of a condensable component leads to more than simple diffusive transport, there is a significant "volumetric extinction" of that component as it condenses, which generates a local drop of air pressure, leading then to the development of wind propelling pressure gradients. The relevance of this finding is such that this new force is in the root of the powerful explanation of hurricanes in the DP, and it has been suggested by the authors in the HESSD discussions [7,8] that the same effect is responsible for the main part of all the atmospheric circulation. Considering the power of this new theoretical formulation for explaining a wide range of atmospheric phenomena, I am inclined to credit this discovery as potentially the most important finding in many years, a con-

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tribution with capacity to deeply revolutionize all atmospheric sciences. In an age of utter climate uncertainty and grave degradation of the planetary environment, an advance such as this merits all possible recognizance and a speedy absorption into the atmospheric science community.

In conclusion, I deem this DP a groundbreaking contribution to science, one that deserves quick publication. However, I would like to suggest that an expansion of section 4, with the inclusion of a full account of their new hurricane theory would not only be in order, but it would save precious time for the community which can gain access and start to work immediately on the new physics. In that sense, I believe also that several important new developments have appeared in the present discussion, mentioning especially the new latent work concept, which extends still further the power of the evaporative force explanation, and builds a strong bridge in the understanding of gas phase transitions as circulation drivers.

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

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