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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Where do winds come from? A new theory on how water vapor condensation influences atmospheric pressure and dynamics" *by* A. M. Makarieva et al.

G. Bryan

gbryan@ucar.edu

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I do not have time to review all the material that has been posted on this site by Makarieva et al. However, I feel compelled to reply to the erroneous statements in an "Author Comment" by Makarieva et al. about how condensation rate is determined in my numerical model (CM1), as described in Bryan and Fritsch (2002) (hereafter BF02).

Makareiva et al's comments (hereafter MC) are based on the conclusion that BF02's Eqn 27 determines the condensation rate in CM1. However, BF02 make clear (pg 2920) that their Eqn. 27 is used to generate a "guess" for the condensation rate.

The actual amount of condensation is determined *diagnostically* through an iterative procedure that simultaneously adjusts nondimensional pressure π, potential temperature θ, water vapor mixing ratio r_v, and cloudwater mixing ratio r_c. The final value of condensation rate $\dot{r}_{\text{cond}}$ (that is, the value actually used in the model integration) is not required to be equal to the first guess; as a matter of fact, the final value is almost never equal to the first guess.

To clarify, the actual equations that are used to determine condensation rate in CM1 are the final terms on the right side of BF02's Eqns. 21–24 (i.e., the terms containing $\dot{r}_{\text{cond}}$) under the constraint that $r_v \leq r_{\text{vs}}(\pi, \theta)$. Total mass and total energy are conserved during this procedure *by formulation*. The conservation properties of the entire modeling system are documented in Fig. 7 of BF02.

For readers not familiar with numerical models, I note that there are more equations in numerical models than simply the time-dependent equations. CM1 also uses the equation of state (Eqn. 9 in BF09), which is used to *diagnostically* determine dry-air density ρ_a. Hence, CM1 does not use a time-dependent equation for ρ_a. Other models integrate a time-dependent equation for density and *diagnose* pressure for use in the momentum equations; this method was advocated by Ooyama (2001). CM1 also uses the criterion $r_v \leq r_{\text{vs}}$; in saturated conditions (for which $r_v = r_{\text{vs}}$ and $r_c > 0$) this means saturated equilibrium; in subsaturated conditions ($r_v < r_{\text{vs}}$) the cloudwater content is zero. CM1 also uses the Clausius-Clapeyron equation and the definition of a mixing ratio r to define the functional form of $r_{\text{vs}}(\pi, \theta)$.

An important point here is that CM1 does not have an explicit equation for condensation rate; rather, condensation rate is determined diagnostically, subject to several additional equations. As far as I know, relations for condensation rate can only be made with a large set of simplifying approximations (such as those used in the article by Makarieva et al. that is under review). Such approximations are not be suitable for a numerical model like CM1.

Because of their fallacious interpretation of how $\dot{r}_{\text{cond}}$ is determined in CM1, the subsequent analyses and conclusions in MC are irrelevant.

Furthermore, the statement by MC that “These expressions were adopted for the BF02 and BR09 models without evaluation of their suitability for the studies in question" is untrue. Extensive testing and evaluation, both numerical and theoretical, was done with the CM1 equations and numerical code. Not all of these tests make it into the peer-reviewed literature.

Finally, I note that the primary purpose of the BF02 article was to provide a method to evaluate moist numerical models. The dynamical similarity of the dry (without condensation) and moist (with condensation) simulations, under the constraints explained therein, demonstrates the accuracy of the method to determine condensation rate.

References

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Ooyama, K. V., 2001: A dynamic and thermodynamic foundation for modeling the moist atmosphere with parameterized microphysics. *J. Atmos. Sci,* **58,** 2073–2102.

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