

Interactive comment on “Comment on “Biotic pump of atmospheric moisture as driver of the hydrological cycle on land” by A. M. Makarieva and V. G. Gorshkov, Hydrol. Earth Syst. Sci., 11, 1013–1033, 2007” by A. G. C. A. Meesters et al.

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Worsening Climate Change, time for agreement and cooperation

Since the original discussion of the Biotic Pump Theory (henceforth BPT) in HESSD (Makarieva & Gorshkov, 2007), a number of distinguished representatives of the meteorological community have manifested their conviction that the proposed evaporative force, the core of the BPT, is just warmed-over coffee, meteorological-trivia rediscovered and misunderstood by non-meteorologists. Maybe resulting from this haughty

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perception, meteorologists had not contemplated responding to Makarieva & Gorshkov (henceforth MG) on more than shallow contempt. Meanwhile, the BPT has grown steadily in importance, both scientifically and in society, remaining for almost two years practically unchallenged by any serious critique from meteorologists.

Until Meesters, Dolman and Bruijnzeel (henceforth MDB) came along and posed this serious questioning to the BPT (Meesters et al, 2009). The MDB comment attempts to reveal and demonstrate fundamental physical flaws in the BPT, especially in the evaporative force concept. This comment is a brave and valuable move to discuss fundamental physical principles and deep theories, an initiative arising from a community otherwise more in tune with explorations of data relationships and development of empirical models. MDB have summarized with didactic competence the standard meteorological understanding of the atmospheric physical processes related to the vertical distribution of water vapor and associated phenomena of molecular (component) and mass (bulk) movements. And in choosing to mathematically express their understanding of these physical processes, MDB have offered a trafficable (and universal) channel of dialogue to MG. The ensuing rich discussion between MDB and MG reveals a substantiated and honest dialogue with fascinating implications. Thus I am looking with good anticipation for the final revised version of the MDB comment and associated response from the BPT authors, response which can be put together just by compiling and structuring a synthesis of the various short comments posted in the discussion by MG.

The new science in the biotic pump is being accepted by many disciplines as a source of coherent and intuitive explanations, previously unavailable, for a great number of complex atmospheric phenomena. Even public opinion is being illuminated by the simple and powerful concepts proposed by the BPT. In Brazil, for example, the notion of the biotic pump in the Amazon forest has become mainstream in the media and in society; no one seems to doubt the powerful effect of forest evaporation and atmospheric condensation on circulation. This perception is so strong that it is indirectly influencing

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the creation of research opportunities for meteorologists, to investigate implications of the Amazonian biotic pump to the South American moisture transport and distribution (eg. the flying rivers project). Notably, the conventional tropical convection schemes are admittedly inadequate to explain the Amazon water budget (the modeled and real runoff differing by a factor of two not allowing to close any mass balance, eg. Marengo, 2005). Therefore, the BPT arrives just in time to enable a critical re-evaluation of the current understanding of regional circulation and exposure of the implicit physical untenabilities of convective parameterization. But not only on a regional scale. As recently shown (Makarieva et al, ACPD 2009), the biotic pump physics sheds new light on the //geophysical enigmas// of compact circulation events like hurricanes and tornadoes, both challenging the existing theories and providing new insights and predictions.

What mysterious ingredient of the biotic pump makes it readily understandable to educated persons and apparently unintelligible to learned meteorologists? From the exhaustive explanations of MG, only one single effect, and its consequences, remain unacknowledged by MDB: the subtraction of one gas from a gas mixture shall result in a pressure deficit (and drop of air pressure has nothing to do with molecular diffusion); pressure deficit, spatially localized in the atmosphere, produces gradients; gradients of pressure propel surrounding masses to move in; continual removal associated with sustained condensation (from temperature gradient), sustains the pressure gradient that appeared with the previous removal, creating a dynamic spatial //sink//; winds flow towards that area. No need to invoke microscopic vs macroscopic phenomena, just a simple and fundamental gas-physics effect will do. A possible culprit for the concentration gradient confusion in meteorology would be the borrowing of concepts straight from hydraulics to use with the atmosphere. In a liquid mixture, small differences in local concentrations of solutes produce ONLY molecular diffusion gradients, but NOT pressure gradients (liquid is incompressible). From the arguments carefully put forth by MDB and strongly supported by the reviewers in the discussion, it appears they are treating this facet of the atmosphere as if it were composed of an uncompressible fluid, where heterogeneous solute concentrations can produce only diffusion gradients. But

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in a gaseous media, pressure will be indissociable from component concentration. Remove the component in a given area and then you create BOTH, concentration AND pressure gradients to other areas. Concentration gradient spur component diffusion, as everybody agrees, but pressure changes associated with the extinction of one component in the mixture contaminates all other molecules in the vicinity, resulting in mass flows.

In my career I have worked extensively with trace gases and eddy flux covariance. Revising all what I know about gas-physics I realize that the notion proposed in the evaporative force is so physically natural and intuitive that there must be some different explanation for the apparent incomprehension expressed by meteorologists. An insight popped then in my mind, the problem might not be of objective nature, it may rather be a psychological reaction to shock: //How such simple and basic effect could have been missed out entirely by our science?// followed then by emotional aversion: //It cannot be! The evaporative force MUST be a flawed proposition!// Once one reads attentively to MG stunningly clear arguments and thinks about it honestly, it is indeed shocking that the evaporative force effect has been (and continues to be) plainly disregarded by meteorology. Educated people, without preconceived ideas or psychological tension, see into the proposition and understand it, period. Meteorologists see into the proposition, get dumbfounded by its simplicity and, from overconfidence, refuse it with disbelief. If psychology is, as I suggest, the crux of the difference, MDB vs MG will never resolve it by employing objective discussion only, without addressing the subjective part. A psychological background question needs to be addressed using different strategies. Humility and scientific grandeur must play a larger role. With so much at stake, I suggest this is the time for a healthy dialogue in several levels, a time for a kind association in the interest of science and the good of humanity. The power of explanations demonstrated by the BPT can benefit much more than its authors and should not mean any threat to meteorology. Rather, if accepted and implemented, it shall mean a renaissance for a discipline squeezed under mounting pressure of an Earth system in fast (non-linear) transformation and a society less and less happy with the

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weakening capacity of climate models to predict even the immediate future. The well crafted criticism posed by MDB is very valuable to the BPT, as no grand-theory gets established without tough tests and extensive clarifications. But once the self-standing logical arguments dispelling the critique and further explaining the theory are on the table, accepting them appears to me as a sensible attitude. Given the stern status of the world, we no longer have decades to let the traditional Darwinian //fight to the death// dispute between MDB and MG sort out who is the winner.

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//The secret of change is to focus all your energy, not on fighting for the old, but on building the new. Socrates//

Interactive comment on *Hydrol. Earth Syst. Sci. Discuss.*, 6, 401, 2009.

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