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Hydrology and Earth System Sciences Discussions

Interactive comment on "Biotic pump of atmospheric moisture as driver of the hydrological cycle on land" *by* A. M. Makarieva and V. G. Gorshkov

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I am an avian ecologist and also in charge of the Zvenigorod Biological Station of Moscow State University, which represents a 750-ha forest island in a relatively densely populated region near Moscow, Russia. The problems of forest susceptibility to draughts and, generally, sustainability of natural ecosystems, are of our primary concern. Keeping an eye on the activities of the present authors, who publish extensively on this topic, I got to know about this discussion and followed it with attention. I am very glad that with the comment of Prof. Jos van Damme the biological part of this

paper was opened for discussion. I too had my question, but as a biologist was unsure to enter a geophysical journal8217;s forum.

I would first like to mention that I have found the physical discussion of the evaporative force very informative, especially as in the last comments it continued on a level understandable for practically every scientist with a very basic, like high school, physical background. The biotic pump idea, sustained by the empirical graphs in Section 2, is visually appealing in its physics. I understand it such that when water vapor, as a gas, condenses and thus vanishes from the atmosphere, the upper atmosphere rarifies as compared to its equilibrium state. The air flows upward as long as there is evaporation, which sustains condensation, whose effect can be compared to partial 8216;vacuumization8217; of the upper atmosphere. High evaporation from forest canopy creates intensive vertical flow of air from above the forest. The rising air is replaced near the surface by horizontal inputs from adjacent areas, including oceans. Unfortunately, this consideration unequivocally signals to conservation biologists that small fragments of formerly extensive forests have few chances of a long-term survival amidst a large-scale deforestation. As I gather, to compete with the ocean for the horizontal flow of atmospheric water vapor, the forest cover must not only possess high leaf area index but also remain huge.

But precisely the evolutionary biological principles of formation of a continent-scale forest pump are not completely clear to me. If a single tree cannot suck moisture from the ocean, how could such trees have evolved that are able to do so *jointly*, if natural selection acts on individual trees? This is the (quite important) biological question that the authors are attempting to solve in Section 4 by introducing 8220;biotic sensitivity8221;. They say that every one tree in a forest senses the moisture status of its soil and acts accordingly trying to induce more (or less) rainfall or regulating moisture flows from the forest floor. Each 8220;right8221; tree becomes a bit better off (by a small relative magnitude of the biotic sensitivity) than the 8220;wrong8221; trees incapable of moisture regulation. This small bit is, according to the authors,

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sufficient for the natural selection to notice and favor 8220;right8221; trees against 8220;wrong8221; trees.

Prof. van Damme suggested that the authors should develop a population model that would prove their statements. I agree that a follow-up of these ideas might be intriguing, but I would not lay much emphasis on modelling. In my understanding, models per se can rarely prove or discover anything. They rather formalize and express in numeric terms our already existing knowledge of the basic organizing principles of the studied phenomenon. These basic principles, on the other hand, should be verified without sparing time.

Although similar to Prof. van Damme, I find the biotic sensitivity idea potentially promising (and in any case original), here I have a question against its very logic. Perhaps if we consider forest as trees only, selection of 8216;slightly better8217; trees, as dictated by the biotic sensitivity, might indeed lead to formation of a population of trees capable to run the moisture pump. But forest is not trees. It is a complex ecological community. Home territories of many animal species, e.g. all forest birds, encompass a large number of individual trees. Natural selection acts on individual animals in the direction of sustaining and enhancing fitness of particular organisms. Among these animal organisms, some can be 8220;interested8221; in the prosperity of the 8220;right8221; trees and, hence, indirectly, in the maintenance of the biotic pump, while others can be more prosperous in the absence of trees whatsoever. Given the huge number of animal and other non-plant species (like bacteria, fungi) present in the forest, who are incapable of regulating moisture content and evaporation, and given that all these organisms act for their own benefits under the natural selection pressure, it remains entirely unclear how the plant-population-level phenomenon of the biotic pump can persist in the long-term within this apparently chaotic conflict of drastically different biological 8220;interests8221;.

As I noticed, the authors are doing their best to provide an exhaustive response to every comment. I wonder whether these responses are expected by the Editors to

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be incorporated into the single 8216;biotic pump8217; paper, or they will be left for subsequent development of these ideas by the authors themselves or by the participants of this discussion. As a reader, I have to say that the paper as it is already raises, with admittedly defensible arguments, almost a threshold number of novel and thought-provoking issues.

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 3, 2621, 2006.