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樹冠遮断で蒸発した水はどこへ行くのか？ー大陸規模降水を支配している可能性
Where does the evaporated water of canopy interception go? A possibility of dictating continental-scale precipitation

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1. Introduction

In the early 20th century forest hydrologists presumed that forest could feed rain that implies stream flow from the forested areas is higher than that from the other land uses. However, in the late 20th century this assumption has been proved to be incorrect based on the results of the catchment experiments. Nowadays, few forest hydrologists study on the effect of rain increase by forest, and rainfall (R) is regarded as an independent variable to explain the partitioning of rainwater. Nevertheless, the idea of rain increase by forest has not yet been denied. Canopy interception (CI) occupies some 20% of R, but you do not know where it goes after evaporation. CI can be a major source of rain above forest and can affect rainfall distribution on a continental-scale. It is expected that the hypotheses described in the next section would be a breakthrough of this issue. This study presents one of the hydrological approaches to prove this new concept.

2. Hypotheses and scenario of an R-CI interaction

First and foremost, the reason why an enormous quantity of water evaporates by CI has not yet been clarified. For instance, Hashino et al. (2005; Proceedings of Annual Conference Japan Society of Hydrology and Water Resources; In Japanese) observed evaporation rate of 13 mm hour^{-1} for rainfall intensity of 59 mm hour^{-1} with the total rainfall of 420.5 mm brought by a typhoon. Splash droplet evaporation (SDE) can explain a huge amount of evaporation during rainfall (Murakami, 2006; J. Hyrol.) but, the SDE hypothesis gives no information on how water vapor is removed, where it goes and the source of the latent heat. One of the promising solutions for this is evaporative force (EF) proposed by Makarieva and Gorshkov (MG 2007; HESS). This theory states buoyancy works for water vapor in the air since the molar weight of water is lighter than that of air. The more humid the air gets, the stronger buoyancy becomes. Accordingly, EF explains effective evaporation during a rain event under high relative humidity.

MG has proposed another important theory, the Biotic Pump Theory. They advocate that in a forested area water vapor is sucked into the inland from the coastal area due to EF under the condition of high evaporation by forest, and this keeps R constant through the coast to the inland a couple of thousands km away from the ocean.

Murakami (2009; Forest Canopies, NOVA Pub.) integrated the idea of SDE and the theory of EF to hypothecate that water vapor generated by CI is transported back up to cloud due to EF and at the same time the latent heat released in the cloud gets back down to forest canopy that makes up for latent heat of vaporization. This hypothesis can make both ends meet in terms of the water vapor and the latent heat during rainfall.

3. Direction of the studies

To estimate CI using meteorological data hydrologists utilize a conventional boundary-layer theory. However, obviously, it underestimates CI and do not elucidate high evaporation rate, e.g. $>$10 mm hour^{-1} (Murakami, 2007; J. Hyrol.) and you need to clarify the observational facts, i.e. an enormous amount of evaporation, whether the scenario in the previous section is correct or not. A simple experiment can reveal a part of the essences of this phenomenon. Some studies showed that agricultural crops have an equivalent amount of CI with forests, and it is needed to clarify the minimum height of the vegetation that CI begins to decrease with diminishing height. Other studies reported that LAI is insensitive to CI, but there exists the minimum LAI from which CI decrease. These approaches enable the parameterization of CI with respect to vegetation structures. Feeding back these hydrological approaches, though it is a plot scale, to the atmospheric sciences considering the hypotheses in the previous section, we might scale them up to the continental, and could prove the effect of rain increase by forest.

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