降雨中の森林からの蒸発：海洋から森林で覆われた大陸奥地への水蒸気輸送の基本原理
Evaporation from forest during rainfall: a basic principle of moisture transport from the ocean to inland continent

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Introduction

Evaporation of canopy interception *I* accounts for some 20% of rainfall. Because of *I*, evapotranspiration ET from forest is larger than any other surfaces on our planet. However, the amount of *I* estimated by the heat balance equation sometimes severely underestimates the observed values, which has been an enigma. Murakami[1)] proposed that *I* is not evaporation from wet canopy surface but evaporation of splash droplets of raindrops. The objective of the present study is 1) to try to prove splash droplet evaporation (SDE) hypothesis based on measurements, and 2) to combine *I* with the biotic pump theory[2)] that presumes precipitation in the inland of a forested continent is driven by ET of forest.

Methods

Artificial Christmas trees were arranged on a tray and were placed outside under the natural rainfall[3)]. Drainage from the tray as net rainfall P_N and the weight of a single tree to calculate water storage on canopy *S* were measured. Gross rainfall P_G and P_N were measured with a 5-minutes interval and *S* was a 1-minute interval. Separation time of rainfall *Spt* that divides rainfall into each individual rain event was set at 6 hours. The storm break time *Sbt* is defined as an intra-storm separation time and was set at 20 minutes, which divides a rain event into sub-rain events, i.e. 20 minutes ≤*Sbt* < 6 hours ≤*Spt*. *I* during *Sbt* is defined as I_{Sbt}, *I* after rainfall ceases as I_{Aft}, and *I* during rainfall when rainfall is observed as I_R. I_R and I_{Sbt} can be calculated using P_G, P_N and *S*, while I_{Aft} is derived from *S* only.

Results and discussion

Figure shows ΣI_R, ΣI_{Sbt}, and I_{Aft} against P_G on a rain event basis for a Christmas tree stand. I_R and I_{Sbt} are shown as the sum of the values since the rain event usually consists of plural sub-rain events. For P_G > 5 mm I_{Aft} ≈0.5 mm, while ΣI_{Sbt} is almost zero. It is clear that ΣI_R is proportional to P_G. For the largest rain event in Figure (below is called Rain event A) P_G, ΣI_R, ΣI_{Sbt} and I_{Aft} were 84.9 mm, 16.6 mm, 0.5 mm and 0.4 mm, respectively. The largest sub-rain event in Rain event A recorded during nighttime with P_G of 59.6 mm, ΣI_R of 11.6 mm and an evaporation rate of 1.91 mm/h. The results strongly suggest that rainfall *per se* drives evaporation during rainfall, i.e. SDE. Makarieva et al. (2013)[2)] showed precipitation does not decline with increasing distance from the coast in the continent over thousands of kilometers, if it is covered with forest, and vice versa. They presume that large ET of forest sucks water vapor from the ocean, which is called “the biotic pump”. They also proposed a principle that condensation of water vapor circulates air due to reduction in volume. Their theory can explain removal of water vapor from the canopy and supply of latent heat for I_R. As is well known the cause of large ET in forest is *I* and SDE is the main mechanism of *I*. That is to say, SDE is the basic principle of the biotic pump.

References

1) Murakami 2006 J Hydrol 319, 72-82.
2) Makarieva et al. 2013 Theor Appl Climatol 111: 79-96.
3) Murakami and Toba 2013 Hydrol Res Let 7: 91-96.

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